Final Public Report for ESA-059

Introduction:
The Bayer Baytown Industrial Park, Baytown, TX was the focus of a 3-day steam system Energy Savings Assessment (ESA). The Baytown site consists of several Bayer production units as well as third-party production plants. The utility infrastructure at the Baytown site is integrated across the production units. There is also a Calpine cogeneration facility at the site that supplies both steam and electricity to all the production units. The Baytown site has an extremely high level of metering up to the battery limits. This allows the Utilities personnel to understand, track and trend demand and usage of the different production units. The steam distribution system has several different pressure headers. The production units are provided a credit for generating steam that is fed into the appropriate site header system. The Baytown site utilities department also operates a dual-fuel fired boiler that burns an alternate fuel in addition to natural gas. This Boiler is base-loaded and the swing in the steam demand is supported by the steam supply from the Calpine cogeneration facility.

Objective of the ESA:
The main objectives of the ESA were as follows:

- Identify steam system energy savings opportunities for the boiler (generation area) and the overall plant steam distribution and condensate return system
- Use the DOE Steam tools such as the Steam System Scoping Tool (SSST), Steam System Assessment Tool (SSAT) and the 3E Plus insulation software to model the steam system at the Bayer Baytown Industrial Park
- Assist Bayer plant personnel to gain familiarity and the ability to use all of the above mentioned tools to identify energy efficiency improvement opportunities at the plant and quantify the potential energy savings associated with the steam system

Focus of Assessment:
Environmental Control Department & Utilities Boiler and the associated site steam system

Approach for ESA:
The ESA plant team included personnel from the Environmental Control Department & Utilities (ECDU) that have varied responsibilities for the steam system ranging from Operations, Maintenance, Reliability and Process Control. William Linder and Lary Durant completed the Steam System Scoping Tool (SSST) on the steam system and provided it to the ESA specialist prior to the start of the ESA. After the initial walk-through of the system, the plant team decided to focus on generation, distribution and recovery. The end-use of steam is extremely complex and widespread at the site and was out of the scope of this Steam ESA. William Linder downloaded the Steam System Assessment Tool (SSAT) and the 3EPlus from the DOE website to quantify potential steam system efficiency opportunities for natural gas and electrical energy savings. A 3-pressure header steam system was used to model the steam system at the plant. The SSAT model was then used to quantify the identified potential energy savings opportunities. The necessary data required for use in the SSAT model was collected from the PI data and historian system during the ESA.

General Observations of Potential Opportunities:
There is a significant level of industry bestpractices in place at the Bayer Baytown Industrial Park, which is reflected in the score that the plant received on the SSST. Additional potential energy savings opportunities were evaluated using the 3-pressure header model of the SSAT.

The steam system at the site has one dual fuel-fired (natural gas and an alternate fuel) boiler with a total capacity of ~200,000 lb/hr that is operated by ECDU. Total annual natural gas usage for this boiler was greater than 1,000,000 MSCF in 2005. Steam and electricity is also purchased from the Calpine cogeneration facility in addition to the steam that is produced in waste heat recovery boilers at some of the production units at the site. Total annual electricity usage for the entire Baytown site is greater than 1.5 billion kWh.

Since the ECDU boiler is base-loaded and is actually in service to burn the alternate fuel, any steam savings opportunities that are identified will not necessarily result in energy (steam) savings from the boiler. The overall effect of these opportunities will be seen as the reduction in the Calpine steam demand. It has to be noted that the steam system model in SSAT has been created using the ECDU boiler as the main boiler but when the savings are calculated they are appropriately proportioned to reflect the steam cost ratio between the ECDU boiler and Calpine steam. Secondly, the deaerator and condensate systems serve all the waste heat recovery boilers of the production plants and any direct savings from flash steam recovery, blowdown, etc. also need to be appropriately proportioned to reflect the fraction of the steam produced by the ECDU boiler.

Based on the Steam ESA on the overall plant steam system, there are natural gas fuel savings opportunities in the steam generation area of the ECDU boiler. There is also a significant opportunity across production units since some heat recovery boilers produce low pressure steam which cannot be used within their battery limits at this time and must be vented. There are also electrical energy savings opportunities that were evaluated during this steam ESA. The energy savings opportunities that were identified are described briefly below and classified as Near, Medium and Long term (please refer to the definitions at the end of the report).

1. **Improve boiler efficiency – Use automatic oxygen trim controller (Near Term Opportunity)**
   Currently, the ECDU boiler has an automatic oxygen trim controller but operators use a manual control to adjust the damper to maintain certain oxygen levels. As a result of the manual control, operation close to the set point is not possible because there could be a small swing in the amount of fuel ratio (alternate fuel vs. natural gas) and could result in emissions exceeding permit levels. Hence, the boiler operators use a safety margin on the excess flue gas oxygen to allow them some time to respond. Based on the natural gas stack loss chart, operating the boiler at the set point value could result in potential energy savings up to 0.5%. Since the automatic oxygen trim controller is already installed and programmed, there is not going to be any capital cost involved in implementing this energy savings opportunity. It has to be noted that operators have had problems previously with the automatic oxygen trim controller and its inability to control flue oxygen levels. If this is observed again then it is recommended to do a root-cause analysis to determine why the automatic controller does not work.

2. **Optimize ratio of natural gas to alternate fuel (Near Term Opportunity)**
   Currently, the ECDU boiler has a set natural gas to alternate fuel flow ratio. This opportunity evaluates the need to optimize this ratio. There are several constraints in this problem such as: Lower limit of FFR; Minimum amount of natural gas flow required for burner operation; Environmental permits on CO, NOx, etc. Nevertheless, there are potential cost savings that can be realized, if the FFR can be lowered. This opportunity evaluates the cost savings potential when the FFR is lowered by ~25%. This will reduce the amount of steam produced by the boiler because the natural gas requirement will be reduced. Since the plant steam demand has not changed, the reduction in steam produced by the boiler will be supplemented by the Calpine steam. The cost of steam generation at Calpine is less than the cost of producing steam in the ECDU boiler which will result in direct cost savings. Although, there is no change in steam demand, there will be net fuel savings since the Calpine facility cogenerates and has a higher overall energy conversion efficiency. Evaluation of net fuel savings for this opportunity is out of the scope of this ESA. It is recommended that the reduction of FFR be done in small steps, then the boiler be operated at those conditions for a week to gain a comfort level and then additional FFR reduction be done and the procedure repeated.

3. **Implement blowdown flash to supply steam to deaerator (Near Term Opportunity)**
   The ECDU boiler has a blowdown flash tank that vents steam to the ambient. The saturated water coming out as blowdown has a significant amount of thermal energy. Flashing this blowdown at the deaerator pressure produces ~30% flash steam. This steam can be utilized in the deaerator, there by reducing the overall steam demand of the deaerator. This opportunity requires piping reconfiguration along with a control valve and can be implemented in the immediate future. This opportunity had been previously identified by unit personnel and is included in a project currently under design. The ESA has provided additional justification for the project to move forward.

4. **Implement blowdown heat recovery exchanger (Near Term Opportunity)**
   The steam generation area at ECDU, near the Boiler, has a blowdown heat recovery exchanger but it is not in service. Implementing the use of this exchanger wherein, the saturated liquid from the blowdown flash tank heats up the make-up water allows for thermal energy recovery which would reduce the amount of fuel required in the boiler. This heat exchanger also reduces the temperature of the blowdown stream. This would also result in additional savings by reducing the cooling requirements that are required prior to the blowdown stream being released to the trench. This opportunity had been previously identified by unit personnel and is included in a project currently under design. The ESA has provided additional justification for the project to move forward.

5. **Reduce excess low pressure steam venting (Near Term Opportunity)**
   Although the end-use (production units) of steam was out of the scope of the ESA, the plant lead and the ESA Specialist drove around the whole Bayer Baytown Industrial Park site, to identify steam venting from the different production plants. One of the production units had low pressure excess steam that was being vented. This can be recovered and used in the deaerator. There is currently a project underway at the plant to capture this steam. The ESA evaluation further confirmed the need to expedite the implementation of this project. Another production unit was observed flashing steam that could potentially be captured. Note that some of the excess steam venting also occurs at third-party plants and they are not under the jurisdiction of BMS.

6. **Add operation of back-pressure steam turbine from HP–LP (Medium Term Opportunity)**
Steam is produced at over 700 psig and then reduced to different pressure levels using pressure reducing valves (PRV), for use in different production units. Instead of using a PRV to reduce pressure, use of a back-pressure steam turbine that operates between the high pressure and low pressure would also generate electricity. Alternatively, the steam turbine can be directly connected to a pump, fan, compressor or any other existing motor-driven equipment. This results in direct electrical energy savings at the expense of a slight increase in the fuel energy due to increased steam production. Note that the plant site had back-pressure steam turbines previously and operators mentioned about severe maintenance and reliability issues with the steam turbines. To ensure success of this opportunity, it has to be ensured that these problems do not occur in the future.

7. **Use of variable frequency drive or a 2-speed drive on combustion fan motors (Medium Term Opportunity)**
Detailed evaluation of the ECDU boiler operation indicates that it operates at a relatively flat average load. This is because the boiler's primary goal is to burn of the alternate fuel at a fixed rate. The main combustion fan and the FGR fan are fixed speed fans. The flow through these fans is controlled by discharge damper operation. Electrical energy savings are possible by using a variable frequency drive on these forced draft centrifugal fans due to the cubic relationship between power and flow rate. Allowing the firing rate to proportionately control the fan speed would result in these energy savings.

8. **Other opportunities & BestPractices**
During the course of the ESA, there were several other opportunities that were briefly investigated but a much more detailed due diligence is required to quantify energy savings and implementation. Additionally, some bestpractices that can be put into practice immediately are also mentioned in this section.

- Continue boiler real time monitoring and add trending of efficiency (BestPractice)

The ECDU boiler data is currently collected in the PI-system. With some very simple equations, boiler efficiency can be calculated real-time and trended. This will allow for use of boiler efficiency as a way to track performance of the boiler as well as any predictive maintenance issues that may be upcoming in the immediate future.

- Recalibrate unit flowmeters to confirm condensate mass balance (BestPractice)

Due to the complex and integrated steam and condensate loop, the condensate return calculation can have significant errors. Calibrating the unit flowmeters to accurately measure condensate flow can mitigate these issues. The amount of condensate returned from each of the units allows the plant personnel to track condensate lost and its location. They then follow up with any maintenance or investigation as needed.

- Synergistic use of low pressure steam / waste heat across battery limits (Long Term Opportunity)

All the production units within the Bayer site are probably well optimized within their battery limits. But there still exist some opportunities wherein low pressure steam or waste heat from one plant could be used to provide energy to another. One classic example of such synergy is preheating of streams, which may be obvious. Another option is to use the waste heat to drive an absorption chiller or refrigeration unit to provide chilled water or refrigeration. This would require additional investigation of the thermal (heat and cold) demands of the production units.

Management Support and Comments:
Management has not set defined energy reduction goals for the site but the plant personnel are actively pursuing energy saving opportunities that are economically viable. Plant personnel spent three full days working with the ESA Specialist and will continue to work to identify projects site-wide thereby re-affirming their goals, strategy and commitment to implementing energy saving opportunities.

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The definitions for Near Term, Medium Term, Long Term opportunities are as follows:

- Near term opportunities would include actions that could be taken as improvements in operating practices, maintenance of equipment or relatively low cost actions or equipment purchases.
- Medium term opportunities would require purchase of additional equipment and/or changes in the system such as addition of recuperative air preheaters and use of energy to substitute current practices of steam use etc. It would be necessary to carryout further engineering and return on investment analysis.
- Long term opportunities would require testing of new technology and confirmation of performance of these technologies under the plant operating conditions with economic justification to meet the corporate investment criteria.